
**1 100 वोल्ट की और तक की कार्यकारिता
वोल्टता के लिए हैलोजन मुक्त
ज्वाला रोधी केबल — विशिष्टि**

**Halogen Free Flame Retardant
(HFFR) Cables for Working
Voltages up to and including
1 100 Volts — Specification**

ICS 29.060.20

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards after the draft finalized by the Power Cable Sectional Committee had been approved by the Electro technical Division Council.

This standard covers the requirements for halogen free flame retardant cables/cords.

In the formulation of this standard, assistance has been derived from the following standards:

IS 694 : 2010	PVC insulated unsheathed and sheathed cables/cords with rigid and flexible conductor for working voltage upto and including 1100 V with amendments
IS 1070 : 1992	Reagent grade water — Specification (<i>third revision</i>)
IS 8130 : 2013	Conductors of insulated electric cables and flexible cords — Specification
BS 7655-6.1 : 1997	Specification for insulating and sheathing materials for cables. Thermoplastic sheathing compounds having low emission of corrosive gases, and suitable for use in cables having low emission of smoke when affected by fire
BS 7655-8.1 : 2000	Specification for insulating and sheathing materials for cables. Crosslinked sheathing compounds having low emission of corrosive gases, and suitable for use in cables having low emission of smoke when affected by fire
BS EN 50267-2-2 : 1999	Common test methods for cables under fire conditions. Tests on gases evolved during combustion of materials from cables. Procedures. Determination of degree of acidity of gases for materials by Measuring pH and conductivity
BS EN 50363-7 : 2005	Insulating, sheathing and covering materials for low voltage energy cables. Halogen Free, thermoplastic, insulating compounds
BS EN 50363-8 : 2005	Insulating, sheathing and covering materials for low voltage energy cables. Halogen free, thermoplastic sheathing compounds
BS EN 50525-1 : 2011	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750V (U ₀ /U). General requirements
IEC 60092-360 : 2014	Electric installation in ships — Part 360: Insulating materials for shipboard and off shore units, power, control, instrumentation, telecommunication and data cables
IEC 60227 (all parts)	PVC insulated cables of rated voltages up to and including 450/750V
IEC 60684-2 : 2011	Flexible insulation sleeving — Part 2: Methods of test

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed value, or calculated value expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*). The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

HALOGEN FREE FLAME RETARDANT (HFFR) CABLES FOR WORKING VOLTAGES UPTO AND INCLUDING 1 100 VOLTS

1 SCOPE

1.1 This specification covers general requirements of single and multicore cables/cords with rigid as well as flexible annealed bare/tinned copper and aluminium conductor insulated and sheathed (if any) with Thermoplastic or Crosslinked Halogen Free Flame Retardant (HFFR) material for voltages up to and including 1 100 V a.c., 50 Hz, used in power and lighting installations including cables for low temperature applications. These cables may be used on d.c. systems for rated voltages up to and including 1 500 V to earth. These cables are suitable to use for conductor temperature not exceeding 70°C for thermoplastic or 90°C for crosslinked material.

1.2 This standard covers the following categories of cables:

Category code	Cable description
01	Thermoplastic 70°C
02	Thermoplastic 90°C (Sheath only)
03	Crosslinked 70°C
04	Crosslinked 90°C

The category namely thermoplastic or thermoset (crosslinked) in which, compound is placed according to its properties, as determined by specific tests.

1.3 This specification is divided into the following three sections:

Section 1	General requirements
Section 2	Unsheathed Single core cables/cords for fixed and flexible wiring
Section 3	Sheathed/ unsheathed single and multi-core cables/cords for fixed and flexible wiring.

The tests specified in (*see* Section 1, Section 2 and Section 3) of this specification shall meet the requirements specified in IS 8130, for conductors, Annex A and Annex B for HFFR insulation and sheath respectively. The insulation and sheath are tested as per the test methods given in relevant parts of IS 10810 and those specifically specified in this specification.

NOTES

1 The term cord is used for the flexible cables up to 5 cores covering sizes up to 2.5 sq. mm.

2 Cables covered in this standard are suitable for indoor use only.

3 The following types of cables are not covered in this standard:

- a) Telephone cables,
- b) Data transmission cables,
- c) Instrumentation cables, and
- d) Screened communication cables.

2 REFERENCES

The standards listed below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below:

IS No.	Title
1885 (Part 32) : 1993	Electrotechnical vocabulary: Part 32 Electric cables (<i>first revision</i>)
4905 : 2015	Random sampling and randomization procedures (<i>first revision</i>)
8130 : 2013	Conductors for insulated electric cables and flexible cords
10810	Methods of test for cables
(Part 0) : 1984	General
(Part 1) : 1984	Annealing test for wires used in conductors
(Part 2) : 1984	Tensile test of aluminium wires
(Part 3) : 1984	Wrapping test for aluminium wires
(Part 4) : 1984	Persulphate test for copper
(Part 5) : 1984	Conductor resistance test
(Part 6) : 1984	Thickness of thermoplastic and elastomeric insulation and sheath
(Part 7) : 1984	Tensile strength and elongation at break of thermoplastic and elastomeric insulation and sheath
(Part 11) : 1984	Thermal ageing in air
(Part 13) : 1984	Ozone resistant test
(Part 15) : 1984	Hot deformation test

<i>IS No.</i>	<i>Title</i>
(Part 20) : 1984	Cold bend test
(Part 21) : 1984	Cold impact test
(Part 30) : 1984	Hot set test
(Part 43) : 1984	Insulation resistance
(Part 44) : 1984	Spark test
(Part 45) : 1984	High voltage test
(Part 53) : 1984	Flammability test
(Part 58) : 1998	Oxygen index test
(Part 59) : 1988	Determination of the amount of halogen acid gas evolved during combustion of polymeric materials taken from cables
(Part 61) : 1988	Flame retardant test
(Part 63) : 1993	Smoke density of electric cables under fire conditions
(Part 64) : 2003	Measurement of temperature index test

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS1885 (Part 32) and IS 10810 (Part 0) shall apply in addition to the following.

3.1 Rated Voltage — Rated voltage U_0 being the r.m.s voltage between any insulated conductor and earth. Rated Voltage U being the r.m.s voltage between any two-phase conductors of multi core cable.

3.2 Halogen Free Flame Retardant (HFFR) Compound — Combination of materials suitably selected, proportioned and treated of which characteristics constituent is the halogen free flame retardant plastomer or one of its co-polymers. The same term also designates compounds containing halogen free flame retardant polymers and some of its co-polymers.

3.3 Routine Tests — Tests made by manufacturer on all finished cable lengths to demonstrate the integrity of the cable.

3.4 Acceptance Tests — Tests carried out on sample taken from a lot for the purpose of acceptance of the lot.

3.5 Type Tests — Test required to be made before supplying a type of cable covered by this standard on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended applications. These tests are of such a nature that after they have been made, they need not be repeated unless changes are made in the cable materials or design or manufacturing process, which might change the performance characteristics.

3.6 Nominal Value — The value by which a quantity is designated and which is often used in tables. Usually in this standard, nominal values give rise to values to be checked by measurements taking in to account specified tolerances.

SECTION 1 GENERAL REQUIREMENTS

4 MATERIAL

4.1 Conductor

4.1.1 Material

- The conductors shall be composed of annealed bare or tinned of high conductivity copper or aluminium wires complying to IS 8130.
- A separator tape made of suitable halogen free material applied over conductor at the discretion of the manufacturer.
- Electrical resistance* — The resistance of conductor at 20°C per km shall be in accordance with the requirements specified in relevant tables of IS 8130 for the given class of conductor and tested as per IS 10810 (Part 5).
- The classes of the conductors relevant to various types of cables are given in respective sections of this specification, namely, Section 2 and Section 3.
- Conductors of cables for fixed installation shall be circular solid or circular stranded or compacted circular or stranded sector shaped.
- Nominal cross sectional area of conductor of cables covered in this standard are given in respective tables.

4.2 Insulation

4.2.1 The insulation shall be either Thermoplastic or Crosslinked halogen free flame retardant (HFFR) compound conforming to the requirements specified in Annex A of this specification.

Type HFI-TP 70 (thermoplastic) with rated temperature of 70°C and Type HFI- XL 70 / HFI- XL 90 Crosslinked (thermoset) with rated temperature of 70° C /90°C

4.2.2 Application to the Conductor

The insulation shall be so applied that it fits closely on the conductor. It shall be possible to remove it without damage to the insulation itself, to the conductor or to the tin coating if any. Compliance shall be checked by inspection and by visual inspection.

4.2.3 Thickness

The mean value of the thickness of insulation shall be not less than the specified nominal value for each type and size of cable shown in the relevant tables (see Section 2 and Section 3) of this specification.

The smallest of the measured values of thickness of insulation (t_i) shall not fall below the nominal value (t_i) specified in the relevant table by more than $(0.1 \text{ mm} + 0.1 t_i)$.

4.2.4 Mechanical Properties before and after Ageing

The insulation shall have adequate mechanical strength and elasticity within the temperature limits to which it may be exposed in normal use.

The compliance shall be checked by carrying out tensile strength and elongation test, for respective type of compound, as per method given in IS 10810 (Part 7). The applicable test values shall be obtained from Annex A, for appropriate type of compound.

4.3 Fillers

4.3.1 The fillers, if provided, shall be of halogen free flame retardant material.

4.3.2 The filler materials shall be suitable for operating temperature of the cable and compatible with other components of the cable. This shall not be harder than the HFFR material used for insulation and sheath.

4.4 Binder Tape

Binder tape if required, shall also be of suitable material of halogen free in nature.

4.5 Sheath

4.5.1 The sheath shall consist of halogen free flame retardant compound conforming to the requirements of HFS-TP 70 or HFS-TP 90 or HFS – XL 70 or HFS-XL90 given in Annex B.

NOTES

1 Insulation and sheath material shall be compatible with each other as per the temperature rating of the cable.

2 A combination of cross linked insulation and thermoplastic sheath is also permissible.

4.5.2 Application

The sheath shall be applied in a single layer:

- On the core, in the case of single-core cables; and
- On the assembly of cores and fillers or inner covering, if any, in the case of other cables.

The sheath shall not adhere to the cores. A separator, consisting of a film or tape, or talcum powder may be placed under the sheath. This separator shall be compatible with the insulation and sheath materials.

4.5.3 Thickness

The mean value of the thickness of sheath shall not be less than the specified nominal value for each type and size of cable shown in the tables of the particular specifications (see Section 3).

However, the thickness of sheath determined by taking average of number of measurements shall be not less than nominal value (t_s) specified in relevant tables and smallest of the measured value shall not fall below the nominal value (t_s) specified by more than $(0.1 \text{ mm} + 0.15 t_s)$ for single core cables and $(0.2 \text{ mm} + 0.2 t_s)$ for multicore cables.

Compliance shall be checked by testing the dimensional requirements specified in Section 2 and Section 3 and as per test method given in IS 10810 (Part 6).

4.5.4 Mechanical Properties before and after Ageing

The sheath shall have adequate mechanical strength and elasticity within the temperature limits to which it may be exposed in normal use.

The compliance shall be checked by carrying out tensile strength and elongation test, shall meet the requirements given in Annex B.

4.5.5 Overall Dimensions

The maximum overall dimensions of the cables shall be within the limits specified in the Table 3 to Table 8 given in Section 2 and Section 3 of this specification.

4.5.5.1 Ovality

The difference between maximum and minimum measured values of overall diameter of sheathed circular cables shall not exceed 15 percent of the maximum measured value at the same cross section.

4.5.6 Colour of Sheath

The preferred colour of the sheath is black. Any other colour agreed to between the purchaser and manufacturer is also permissible

5 TESTS

The testing on the cables will be conducted as given Table 2. For each category of cables listed under scope of this standard.

Unless otherwise stated, the tests shall be carried out in accordance with appropriate part of IS 10810, taking into account the additional information given in this standard.

5.1 High Voltage Test (at Room Temperature) (Acceptance and Routine Test)

In case of multicore cables and cords test voltage shall be applied for a period of 5 min between the cores.

Single-core cables shall be immersed in water at ambient temperature one hour before the testing and the test voltage shall be applied between conductor and water for the specified period.

Cables/cords tested as above shall withstand without breakdown an a.c. voltage of 3 kV (r.m.s) or a d.c. voltage of 7.5 kV for 5 min.

5.2 Spark Test (Routine Test)

Spark test may be carried out as an alternate to high voltage on single core unsheathed cables. The voltage shall be as specified below:

<i>Thickness of Insulation (mm)</i>	<i>Test Voltage (kV) (r.m.s)</i>
Up to and including 1.0	6
Above 1.0 and up to and including 1.5	10
Above 1.5 and up to and including 2.0	15
Above 2.0 and up to and including 2.5	20
Above 2.5	25

5.3 Flammability Test

The test shall be conducted as per IS 10810 (Part 53). The period of burning after removal of flame shall not exceed 60 s and the unaffected (uncharred) portion from the lower edge of the top clamp shall be at least 50 mm.

5.4 Oxygen Index Test

The test shall be conducted as per IS 10810 (Part 58), on samples at $27 \pm 2^\circ\text{C}$.

The oxygen index shall not be less than 31.

NOTE — This test is not applicable for cable produced with crosslinked compounds.

5.5 Test for Temperature Index

The test shall be conducted as per IS 10810 (Part 64).

The minimum measured value of temperature index shall be 250°C at which the oxygen index is 21.

NOTE — This test is not applicable for cable produced with crosslinked compounds.

5.6 Smoke Density

The test shall be conducted as per IS 10810 (Part 63). The minimum transmittance of light shall be 70 percent.

5.7 Assessment of Halogen

This test is done to determine the presence of halogen and to sequential test programme as given in Table 1 of Annex D. The detailed step by step sample testing sequence shall be as per Table 2 of Annex.4. For detailed test procedure refer Annex D.

5.8 Toxicity Index Test

Under consideration.

5.9 Flex Test

Under consideration.

5.10 Persulphate Test

The tinned copper conductor shall meet the requirement as specified in IS 8130, and test be conducted as per IS 10810 (Part 4).

5.11 Flame Retardant Test

The test shall be conducted as per IS 10810 (Part 61), on single core cable and after the test, there shall be no visible damages on the test specimen within 300 mm from its upper end.

5.12 Hot Set Test (*see also Sl. No. 5 of Annex A*)

The insulation of heat resistance cross linked HFFR (HFI-XL70, HFI-XL 90, HFSXL70, HFS XL 90) cable are subjected to this test and the elongation percent under load shall be maximum 175 percent and permanent set shall be maximum 15 percent when tested as per IS 10810 (Part 30).

5.13 Water Immersion Test (Effect of Water on Sheath)

This test represents the influence of water on the mechanical properties of sheath through tensile strength and elongation at break on untreated and treated samples after water immersion. The test results on the conditioned and unconditioned samples shall not have any significant change. The test samples are immersed into the de-ionized water for the temperature and duration as specified in Sl. No. 8 of Annex B. After the water immersion, the sample shall be cooled off to $20 \pm 5^\circ\text{C}$ before taken out of water. The test samples are removed off the moisture using tissue paper and the tensile strength and elongation at break tests are conducted within 40 min as per IS 10810 (Part 7).

5.14 Ozone Resistance Test (*see also Sl. No. 8 of Annex A*)

This test shall be conducted as per IS 10810 (Part 13).

5.15 Cold Bend Test (*see also Sl. No. 6 of Annex A*)

This test shall be conducted as per IS 10810 (Part 20).

5.16 Cold Impact Test (*see also S. No. 7 of Annex A*)

This test shall be conducted as per IS 10810 (Part 21).

6. CORE IDENTIFICATION

Core identification shall preferably be as per Table 1 of this standard. Any other colour agreed to between the purchaser and manufacturer is also permissible

6.1 General Requirements

Identification of the cores of a cable shall be achieved by the use of coloured insulation or other suitable method (as per Table 1). The colouring with skin type is allowed provided it meets the desired testing as given in the specification.

The colours shall be clear, identifiable and durable. Durability shall be checked by the test given in 6.2.2.

6.1.1 Colour Combination Green-Yellow

In case of Green-Yellow cables used for earthing, the distribution of the colours shall comply with the following condition:

For every 15 mm length of core, one of these colours shall cover at least 30 percent and not more than 70 percent of the surface of the core, the other colour covering the remainder.

6.2 Core Identification by Numbers

In case of core identification with help of numbering instead of colour identification following shall be applicable:

The insulation of the cores shall be of the same colour preferably in black and numbered sequentially, except for the core coloured green-yellow, if one is included.

The green-yellow core, if any, shall comply with the requirement of 6.1.1 and shall be in the outer layer, as last core.

The numbering shall start by number 1 in the inner layer.

The numbers shall be printed in 'Indo-Arabic' numerals on the outer surfaces of the cores.

All the numbers shall be of the same colour, which shall contrast with the colour of the insulation. The numerals shall be legible.

6.2.1 Preferred Arrangement of Marking

The numbers shall be repeated, at regular intervals along the core, consecutive numbers being inverted in relation to each other.

When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm (see Fig. 1).

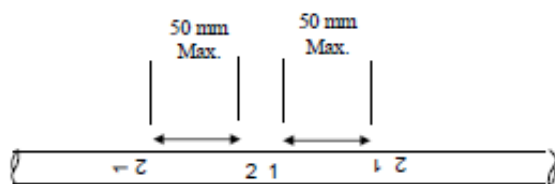


FIG. 1 PREFERRED ARRANGEMENT OF MARKING

6.2.2 Durability

Printed numerals shall be durable. Compliance with this requirement shall be checked by gently rubbing the print using wet cloth 10 times without generating heat locally. The print shall still remain clear and legible.

7 CABLE CODE

The following code shall be used for designating the cable:

Constituent	Code Letter
Aluminium conductor	A
HFFR thermoplastic insulation	Z
HFFR thermoplastic sheath	Z
HFFR thermoset insulation	XZ
HFFR thermo set sheath	XZ

NOTE — No code letter for conductor is required when the conductor material is copper.

8. SAMPLING OF CABLE

See Annex C.

9. IDENTIFICATION

The manufacturer shall be identified throughout the length of the cable by manufacturers' name or trade-mark being printed, indented or embossed on the insulation in case of single core cable and on the sheath in case of sheathed cable. In case none of these methods can be employed, or the purchaser so desires, colour identification threads in accordance with the scheme to be approved by Bureau of Indian Standards shall be employed which shall be free from halogen content. The distance between two consecutive prints shall not greater than 1 000 mm.

The Marking shall be legible and indelible and it shall be checked, as per 6.2.2.

10 PACKING AND MARKING

10.1 The cable shall be either wound on drums, reels or supplied in coils.

10.2 The cable (packed in coil, reel or drum) shall carry the following information either stenciled on the reel or drum or contained in a label attached to it:

- Reference to this Indian Standard;
- Manufacturer's name, brand name or trade mark;
- Type of cable and voltage grade;
- Number of cores;
- Nominal cross-sectional area of conductor;
- Cable code;
- Colour of core (in case of single core cables);
- Length of cable on the reel, drum or coil;
- Number of lengths on the reel, drum or coil (if more than one);
- Direction of rotation of drum (by means of arrow);
- Country of manufacture; and
- Year of manufacture.

10.2.1 BIS Certification Marking

The standard may also be marked with the standard mark.

10.2.1.1 The use of Standard Mark is governed by the *Bureau of Indian Standards Act, 2016* and the

rules and Regulations Made thereunder. The details of the conditions under which the licence for use of the Standard Mark may be granted to manufacturer and producers may be obtained from the Bureau of Indian Standards.

Table 1 Core Identification

(Clause 6)

No. of Cores	Cables for Fixed Wiring	Flexible Cords
(1)	(2)	(3)
1	Red, black, yellow, blue, white or grey	Red, black, yellow, blue, white, grey or green-yellow
2	Red and black	Red and black
3	Red, yellow and blue	Red, black and yellow-green or red, yellow and blue
4	Red, yellow, blue and black	Red, yellow, blue and yellow-green or red, yellow, blue and black
5	—	Red, yellow, blue, black and grey or yellow, blue, green white and yellow-green
6	—	Red, yellow, blue, green, white and yellow-green. Alternatively insulated cores shall be of same colour preferably black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow green core in outer most layer if required
7	—	Red, yellow, blue, green, white, black and yellow-green Alternatively insulatedcores shall be of same colour preferably black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow green core in outer most layer if required
8	—	Red, yellow, blue, green, white, black, grey and yellow-green Alternatively insulated cores shall be of same colour preferably black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow green core in outer most layer if required
9	—	Red, yellow, blue, green, white, black, grey, yellow-green, orange/brown. Alternatively insulated cores shall be of same colour preferably black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow green core in outer most layer if required
10	—	Red, yellow, blue, green, white, black, grey, yellow-green, orange and brown. Alternatively insulated cores shall be of same colour preferably black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow green core in outer most layer if required
11	—	Red, yellow, blue, green, white, black, grey, orange, brown, pink and yellow-green. Alternatively insulated cores shall be of same colour preferably black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow green core in outer most layer if required
12	—	Red, yellow, blue, green, white, black, grey, orange, brown, pink , violet and yellow- green. Alternatively insulated cores shall be of same colour preferably black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow green core in outer most layer if required
13-25	—	Two adjacent cores in each layer blue and Yellow (counting and direction core), and other remaining cores – Grey with or without number printing. Alternatively insulated cores shall be of same colour preferably black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow green core in outer most layer if required
	—	

NOTES

1 In case of single-core cables used for control wiring of switchgear, any colour other than the above shall be permissible as agreed to between the Purchaser and the Supplier.

2 The colour of insulation for parallel twin flexible cords may be any two of red, black, yellow, blue, white and grey. The cores may be identified by a longitudinal rib on one core in case of same colour of the cores.

3 For cables and cords with more than five cores, as an alternative, it is permissible to have all cores of the same colour. In such case, the cores shall be numbered sequentially (Hindu-Arabic numerals printed on the surface of the cores), starting with “1” for the innermost layer. The gap between two successive printings shall not exceed 50 mm.

Table 2 Tests
(Clause 11.4, 12.4, 13.7 14.7 and 15.7)

Tests		Requirements, Ref. to IS No./Clause of this Standard	Method of Test, Ref. to Part of IS 10810	Category
(1)		(2)	(3)	(4)
I	Routine Tests			
	a) HV test or spark test	5.1 5.2	45 44	01,02,03,04
	b) Conductor resistance test 20°C	4.1.1(c)	5	01,02,03,04
II	Acceptance Tests			
	a) Tensile test (for aluminium)	IS 8130	2	01,02,03,04
	b) Wrapping test (for aluminium)	IS 8130	3	01,02,03,04
	c) Persulphate test for tinned copper	IS 8130	4	01,02,03,04
	d) Conductor resistance test	IS 8130	5	01,02,03,04
	e) Test for thickness of insulation and sheath, diameter of core and sheath including ovality of sheath	11.2, 11.3, 12.2, 12.3, 13.2, 13.4, 13.5, 13.6, 14.2, 14.4, 14.5, 14.6, 15.2, 15.4, 15.5 and Table 3 to 8	6	01,02,03,04 01,02,03,04 01,02,03,04
	f) Tensile strength and elongation at break of insulation and sheath	Annex A and 2	7	01,02,03,04
	g) Insulation resistance	Annex A	43	01,02,03,4
	h) High voltage test	5.1	45	01,02,03,04
	j) Flammability test	5.3	53	01,02,03,04
	k) pH and conductivity	5.7 and Annex D	—	01,02,03,04
	m) Hot set test	Annex A	30	03,04
III.	Type Tests			
	a. Conductor			
	i) Conductor resistance test	IS 8130	5	01,02,03,04
	ii) Annealing test (for copper)	IS 8130	1	01,02,03,04
	iii) Persulphate test for tinned copper	IS 8130	4	01,02,03,04
	iv) Tensile test (for aluminium)	IS 8130	2	01,02,03,04
	v) Wrapping test for aluminium)	IS 8130	3	01,02,03,04
	b. Test for Overall Dimensions and Thickness of Insulation and Sheath	11.2, 11.3, 12.2, 12.3, 13.2, 13.4, 13.5, 13.6, 14.2, 14.4, 14.5, 14.6, 15.2, 15.4, 15.5 and Table 3 to 8	6	01,02,03,04
	c. Tests on Insulation			
	i) Tensile strength and elongation at break before and after ageing	Annex A	7 and 11	01,02,03,04
	ii) High voltage test	5.1	45	01,02,03,04
	iii) Insulation resistance	Annex A	43	01,02,03,04
	iv) Oxygen index	5.4	58	01,02
	v) Temperature Index	5.5	64	01,02
	vi) Ageing in air oven	Annex A	11	01,02,03,04
	vii) Hot deformation	Annex A	15	01,02,03,04
	viii) Assessment of halogen	Annex D	—	01,02,03,04

Table 2 (Concluded)

Tests		Requirements, Ref. to IS No./Clause of this Standard	Method of Test, Ref. to Part of IS 10810	Category
(1)		(2)	(3)	(4)
	x) Cold impact test	Annex A	21	01,02,03,04
	xi) Hot set test	Annex A	30	03,04
	xii) Ozone resistance test	Annex A	13	01,02,03,04
	xiii) Flame retardant test	5.11	61	01,02,03,04
	d. Tests on Fillers / Dummy Cores and Binder Tapes/ Identification Threads (if Any)			
	i) Assessment of halogen	5.7 and Annex D	—	01,02,03,04
	e. Tests on Sheath			
	i) Tensile strength and elongation at break	Annex B	7	01,02,03,04
	ii) Ageing in air oven	Annex B	11	01,02,03,04
	iii) Oxygen index	5.4	58	01,02
	iv) Temperature Index	5.5	64	01,02,
	v) Ozone resistance test	Annex A	13	01,02,03,04
	vi) Hot deformation	Annex B	15	01,02,03,04
	vii) Assessment of halogen	5.7 and Annex D	—	01,02,03,04
	viii) Hot set test	Annex B	30	03,04
	f. Tests on Finished Cable			
	i) High voltage test	5.1	45	01,02,03,04
	ii) Flammability test	5.3	53	01,02,03,04
	iii) Cold bend test	Annex A and B	20	01,02,03,04
	iv) Cold impact test	Annex A and B	21	01,02,03,04
	v) Flame retardant test	5.11	61	01,02,03,04
	vi) Water immersion test (effect of water on sheath of cable)	5.13	—	01,02,03,04
	vii) Smoke density test	5.6	63	01,02,03,04

SECTION 2 UNSHEATHED SINGLE CORE CABLES / CORDS FOR FIXED AND FLEXIBLE WIRING

11 SINGLE CORE UN-SHEATHED CABLES WITH RIGID CONDUCTOR (CLASS 1 OR 2) (MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 90°C)

11.1 Conductor

Conductor shall comply with requirements of IS 8130 for class 1 for solid, and class 2 for stranded conductor. The sizes covered for the conductor are:

- a) 0.5 to 10.0 mm² : Class 1 and 2; and
- b) 16 mm² and above : Class 2.

NOTE — In case of aluminium conductor cables, construction of 4.0 mm² and above only considered.

11.2 Insulation

Insulation shall be halogen free flame retardant compound type HFI-TP 70 or HFI-XL 70 or HFI-XL 90 as per Annex A, applied around conductor by the extrusion process. The thickness shall comply with the specified values given in col 4 of Table 3.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in the Table No. 3 by more than (0.1 mm + 0.1 t_i).

11.3 Overall Diameter

The maximum overall diameter shall not exceed limits given in col 5 of Table 3.

11.4 Tests

Compliance with the requirements of 11.1 to 11.3 above shall be checked by inspection and by the tests given in Table 2.

**Table 3 Dimensions of Single Core Halogen Free Flame Retardant Type
Unsheathed Cables with Rigid Conductor (Class 1 or 2)
(Maximum Conductor Temperature 70°C or 90°C)**

(Clauses 11.2 and 11.3)

Sl No.	Nominal Cross-sectional Area of Conductor mm ²	Class of Conductor	Thickness of Insulation (t_i) Nominal mm	Max. Overall Diameter mm
(1)	(2)	(3)	(4)	(5)
i)	0.5	1	0.6	2.3
ii)	0.75	1	0.6	2.5
iii)	1.0	1	0.7	3.1
iv)	1.0	2	0.7	3.2
v)	1.5	1	0.7	3.2
vi)	1.5	2	0.7	3.3
vii)	2.5	1	0.8	3.9
viii)	2.5	2	0.8	4.0
ix)	4.0	1	0.8	4.5
x)	4.0	2	0.8	4.6
xi)	6.0	1	0.8	5.0
xii)	6.0	2	0.8	5.2
xiii)	10.0	1	1.0	6.5
xiv)	10.0	2	1.0	6.7
xv)	16.0	2	1.0	7.8
xvi)	25.0	2	1.2	9.7
xvii)	35.0	2	1.2	10.9
xviii)	50.0	2	1.4	12.8
xix)	70.0	2	1.4	14.6
xx)	95.0	2	1.6	17.1
xxi)	120.0	2	1.6	18.8

Table 3 (Concluded)

Sl No.	Nominal Cross-sectional Area of Conductor mm ²	Class of Conductor	Thickness of Insulation (t _i) Nominal mm	Max. Overall Diameter mm
(1)	(2)	(3)	(4)	(5)
xxii)	150.0	2	1.8	20.9
xxiii)	185.0	2	2	23.3
xxiv)	240.0	2	2.2	26.6
xxv)	300.0	2	2.4	29.5
xxvi)	400.0	2	2.6	33.2
xxvii)	500.0	2	2.8	37.5
xxviii)	630.0	2	2.8	42.0

12 SINGLE CORE UNSHEATHED CABLE WITH FLEXIBLE COPPER CONDUCTOR (MAXIMUM CONDUCTOR TEMPERATURE OF 70°C OR 90°C)

12.1 Conductor

The conductor shall comply with the requirements given in IS 8130 for class 5 conductors. The sizes covered are 0.5 to 300 mm².

12.2 Insulation

The insulation shall be halogen free flame retardant compound HFI-TP 70 or HFI-XL 70 and HFI-XL 90 as per Annex A, applied around the conductor by the suitable process.

The thickness shall comply with specified values given col 3 of Table 4.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in the Table 4 by more than $(0.1 \text{ mm} + 0.1 t_i)$.

12.3 Overall Diameter

The maximum overall diameter shall not exceed the limit given in col 3 of Table 4.

12.4 Tests

Compliance with requirement of **12.1** to **12.3** shall be checked by inspection and by the test given in Table 2.

Table 4 Single Core Halogen Free Flame Retardant Type Unsheathed Cable with Flexible Conductor (Maximum Conductor Temperature 70°C or 90°C)

(Clauses 12.2 and 12.3)

Sl No.	Nominal Cross-sectional Area of Conductor mm ²	Thickness of Insulation (t _i) Nominal mm	Max. Overall Diameter mm
(1)	(1)	(2)	(3)
i)	0.5	0.6	2.6
ii)	0.75	0.6	2.8
iii)	1	0.6	3
iv)	1.5	0.6	3.4
v)	2.5	0.7	4.1
vi)	4	0.8	4.8
vii)	6	0.8	5.3
viii)	10	1	7
ix)	16	1	8.1
x)	25	1.2	10.2
xi)	35	1.2	11.7
xii)	50	1.4	13.9

Table 4 (Concluded)

Sl No.	Nominal Cross-sectional Area of Conductor mm ²	Thickness of Insulation (t_i) Nominal mm	Max. Overall Diameter mm
(1)	(1)	(2)	(3)
xiii)	70	1.4	16
xiv)	95	1.6	18.2
xv)	120	1.6	20.2
xvi)	150	1.8	22.5
xvii)	185	2	25
xviii)	240	2.2	28.5
xix)	300	2.4	32

SECTION 3 SHEATHED SINGLE AND MULTICORE CABLES / CORDS FOR FIXED AND FLEXIBLE WIRING

13 SINGLE AND MULTICORE CIRCULAR HALOGEN FREE FLAME RETARDANT (HFFR) INSULATED AND SHEATHED CABLES WITH RIGID CONDUCTOR (CLASS 1 AND 2) (MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 90°C)

13.1 Conductor

The conductor shall comply with requirements of IS 8130 for class 1 for solid and for class 2 for stranded conductor.

- a) No. of cores — 1, 2, 3, or 4; and
- b) Sizes — 1.0 to 120 mm².

13.2 Insulation

The insulation shall be of halogen free flame retardant compound HFI-TP 70 or HFI-XL 70 or HFI-XL 90 applied around the conductor by the suitable process. The thickness shall comply with specified values given in Table 5.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in the relevant table by more than (0.1 mm + 0.1 t_i).

13.3 Assembly of Cores

The recommended lay up of cores for multicore cables/cords shall be as per Table 9.

13.4 Sheath

The sheath shall be halogen free flame retardant compound type HFS-TP 70 or HFS-TP 90 or HFS-XL 70 or HFS-XL 90, applied around the laid up cores by the suitable process. The sheath shall fit closely and shall be capable of being removed without damage to the inner core. The sheath thickness shall comply with specified values given in Table 5.

The thickness of sheath determined by taking average (t_s) of number of measurements, shall not be less than nominal value (t_s) specified in Table 1 and the smallest of the measured values shall not fall below nominal value specified in Table 5 by more than 0.15 t_s + 0.1 mm for single core cables and 0.2 t_s + 0.2 mm for multicore cables.

The colour of sheath shall preferably be black or any other colour as agreed between the purchaser and supplier.

13.5 Ovality

The difference between maximum and minimum measured values of overall diameter of sheathed circular cables shall not exceed 15 percent of the maximum measured values at the same cross section.

13.6 Overall Dimensions

The maximum overall dimensions shall be within the upper limit as given in Table 5.

13.7 Tests

The compliance with the requirement of 13.1 to 13.5 and shall be checked by inspection by test given in Table 2.

14 SINGLE AND MULTICORE CIRCULAR HALOGEN FREE FLAME RETARDANT (HFFR) INSULATED AND SHEATHED CABLES WITH FLEXIBLE CONDUCTOR (CLASS 5) (MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 90°C)

14.1 Conductor

The conductors shall comply with requirements given in IS 8130 for class 5 conductor.

- a) Number of cores — 1, 2, 3, 4, 5; and
- b) Sizes covered — 4.00 to 300 mm².

14.2 Insulation

The insulation shall be halogen free flame retardant compound HFI-TP 70 or HFI-XL 70 or HFI-XL 90, applied around each conductor by the process of extrusion. The insulation thickness shall comply with specified values given in Table 6.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in the relevant table by more than $(0.1 \text{ mm} + 0.1 t_i)$.

14.3 Assembly of Cores

The recommended lay up of cores for multicore cables/cords shall be as per Table 9.

14.4 Sheath

The sheath shall be Halogen free flame retardant compound HFS-TP 70 or HFS-TP 90 or HFS-XL 70 or HFS-XL 90 applied around the cores by the process of extrusion. The sheath thickness shall comply with the specified values given in Table 6.

The sheath may fill the space between cores thus forming a filling, but it shall not adhere to the cores. The assembly of cores may be surrounded by a separator, which shall not adhere to cores.

The assembly of circular cord shall have a practically circular cross section.

The thickness of sheath determined by taking average of measurements shall not be less than nominal value (t_s) specified in Table 6 and the smallest of the measured values shall not fall below nominal value specified in Table 6 by more than $0.15 t_s + 0.1 \text{ mm}$ for single core cables and $0.2 t_s + 0.2 \text{ mm}$ for multicore cables.

The colour of sheath shall preferably be black or any other colour as agreed between the purchaser and supplier.

14.5 Ovality

The difference between maximum and minimum measured values of overall diameter of sheathed circular cables shall not exceed 15 percent of the maximum measured values at the same cross section.

14.6 Overall Dimensions

The maximum overall dimensions of circular cords shall be within the limits given in Table 6.

14.7 Tests

Compliance with the requirements of 14.1 to 14.5 above shall be checked by inspection and by tests given in Table 2.

15 MULTICORE CIRCULAR HALOGEN FREE FLAME RETARDANT (HFFR) INSULATED AND SHEATHED CORDS/CABLES WITH FLEXIBLE CONDUCTOR (CLASS 5) (MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 90°C)

15.1 Construction

The conductors shall comply with requirements given in IS 8130 for class 5 conductor.

- Conductor material — Annealed bared or tinned copper;
- No. of conductors — 1,2,3,4 and 5 for cords, 6 to 25 for cables; and
- Sizes covered — 0.5 to 2.5 mm² for cords/cables, 0.5 to 4.0 mm² for twin twisted/ twin parallel cords/cables.

15.2 Insulation

The insulation shall be halogen free flame retardant compound HFI-TP 70 or HFI-XL 70 or HFI-XL 90, applied around each conductor by the process of extrusion. The insulation thickness shall comply with specified values given in Table 7 and Table 8.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in the relevant table by more than $(0.1 \text{ mm} + 0.1 t_i)$.

15.3 Assembly of Cores

The recommended lay up of cores for multicore cables/cords shall be as per Table 9.

15.3.1 Twisted Twin Unsheathed Flexible Cables/Cords

The cores shall be twisted together with suitable lay.

15.3.2 Twin Parallel(Unsheathed) Flexible Cords

Two conductors shall be laid parallel and insulated simultaneously such that the cores can be separated readily without damage.

15.3.3 Twin Flat Sheathed Flexible Cables /Cords

Two insulated cores shall be laid parallel and sheathed.

15.4 Sheath

The sheath, wherever, applicable shall be of Halogen free flame retardant compound HFS-TP 70 or HFS TP 90 or HFS-TP 90 or HFS – XL 70 or HFS-XL 90, applied around the cores by the process of extrusion. The sheath thickness shall comply with the specified values given in Table 7.

The sheath may fill the space between cores thus forming a filling, but it shall not adhere to the cores. The assembly of cores may be surrounded by a separator, which shall not adhere to cores.

The assembly of circular cord shall have a practically circular cross section.

The thickness of sheath determined by taking average of measurements shall not be less than nominal value (t_s) specified in Table 4 and the smallest of the measured values shall not fall below nominal value specified in Table 7 and Table 8 by more than $0.15 t_s + 0.1$ mm for single core cables and $0.2 t_s + 0.2$ mm. for multicore cables.

The preferred colour of the sheath is black.

Any other colour agreed to between the purchaser and manufacturer is also permissible.

15.5 Overall Dimensions

The maximum overall dimensions of circular cables/ cords shall be within the limits given in Table 7 and Table 8.

15.6 Tests

Compliance with the requirements of **15.1** to **15.5** above shall be checked by inspection and by tests given in Table 2.

Table 5 HFFR Insulated Circular Sheathed Cables For Fixed Wiring
(Clauses 13.2, 13.4 and 13.6)

Sl No.	Nominal Cross-Sectional Area of Conductor	Nominal Thickness of Insulation (t_i)	Nominal Thickness of Sheath (t_s)				Overall Dimensions, Max			
			Single core	Two core	Three core	Four core	Single core	Two core	Three core	Four core
	mm ²	mm	mm	mm	mm	mm	mm	mm	mm	mm
i)	1	0.6	1.1	1.2	1.2	1.2	5.3	8.2	8.8	9.9
ii)	1.5	0.7	1.1	1.2	1.2	1.3	5.9	9.4	10.2	11.5
iii)	2.5	0.8	1.1	1.3	1.3	1.3	6.7	10.9	11.8	13.3
iv)	4	0.8	1.2	1.3	1.3	1.4	7.2	12.0	13.0	14.6
v)	6	0.8	1.2	1.4	1.4	1.4	8.1	13.7	14.8	16.7
vi)	10	1	1.2	1.5	1.5	1.6	9.5	16.5	17.8	20.0
vii)	16	1	1.3	1.5	1.6	1.6	10.6	18.9	20.4	22.9
viii)	25	1.2	1.3	1.6	1.7	1.8	12.2	22.1	23.8	26.8
ix)	35	1.2	1.4	1.7	1.8	1.9	13.6	24.9	26.8	30.1
x)	50	1.4	1.4	1.9	1.9	2.0	15.6	28.7	31.0	34.8
xi)	70	1.4	1.5	2.0	2.0	2.2	17.3	—	34.7	38.9
xii)	95	1.6	1.5	2.1	2.2	2.3	19.2	—	38.9	43.6
xiii)	120	1.6	1.6	2.2	2.3	2.4	20.7	—	42.1	47.2

**Table 6 Flexible HFFR Insulated and Sheathed
Cables (Circular)**
(*Clauses 14.2, 14.4.1 and 14.6*)

Sl No.	Nominal Cross- Sectional Area of Conductor	Nominal Thickness of Insulation (t_i)	Nominal Thickness of Sheath (t_s)					Overall Dimensions, <i>Max.</i>				
			Single core	Two Core	Three Core	Four Core	Five Core	Single Core	Two Core	Three Core	Four core	Five Core
	mm ²	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
i)	4	0.8	1.1	1.3	1.3	1.4	1.4	7.0	11.6	12.5	14.1	15.4
ii)	6	0.8	1.2	1.4	1.4	1.4	—	8.1	13.7	14.8	16.7	—
iii)	10	1	1.2	1.5	1.5	1.6	—	9.6	16.7	18.1	20.3	—
iv)	16	1	1.3	1.5	1.6	1.7	—	10.7	19.1	20.6	23.1	—
v)	25	1.2	1.3	1.7	1.7	1.8	—	12.7	22.9	24.8	27.8	—
vi)	35	1.2	1.4	1.8	1.8	1.9	—	14.2	25.9	28.0	31.4	—
vii)	50	1.4	1.5	1.9	2.0	2.1	—	16.5	30.6	33.1	37.1	—
viii)	70	1.4	1.5	2.1	2.1	2.3	—	18.8	35.1	37.9	42.6	—
ix)	95	1.6	1.6	2.2	2.3	2.5	—	21.4	40.5	43.7	49.0	—
x)	120	1.6	1.7	2.3	2.5	2.6	—	23.0	43.7	47.2	52.9	—
xi)	150	1.8	1.8	2.5	2.6	2.8	—	25.6	-	52.7	59.1	—
xii)	185	2	1.8	2.7	2.8	3.0	—	28.2	-	58.3	65.3	—
xiii)	240	2.2	2.0	2.9	3.1	3.3	—	31.8	-	66.1	74.1	—
xiv)	300	2.4	2.1	3.2	3.3	3.6	—	35.5	-	74.0	83.0	—

**Table 7 HFFR Insulated Sheathed / Unsheathed Flexible Cords and
Flexible Twin Twisted and Twin Parallel Cable and Twin Flat Cords/Cables**
(Clause 15.2, 15.4 and 15.5)

Sl No.	Nominal Cross- Sectional Area of Conductor	Nominal Thickness of Insulation (ti)	Nominal Thickness of Sheath (ts)					Overall Dimensions, <i>Max.</i>							
			Single core	Two core	Three core	Four core	Five core	Single core	Two core	Three core	Four core	Five core	Parallel Twin	Twisted Twin	Twin Flat sheathed
	mm ²	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
i)	0.50	0.60	0.9	0.9	0.9	0.9	0.9	4.3	6.9	7.3	8.0	8.7	2.6 × 5.2	5.2	7.2 × 4.9
ii)	0.75	0.60	0.9	0.9	0.9	0.9	0.9	4.5	7.3	7.7	8.4	9.2	2.8 × 5.6	5.6	7.8 × 5.2
iii)	1.00	0.60	0.9	0.9	0.9	0.9	1.0	4.7	7.6	8.1	8.8	9.6	3.0 × 6.0	6.0	8.0 × 5.4
iv)	1.50	0.60	0.9	0.9	0.9	1.0	1.0	5.4	8.9	9.4	10.4	11.4	3.3 × 6.6	6.6	8.6 × 5.6
v)	2.50	0.70	1.0	1.0	1.0	1.0	1.0	6.2	10.3	10.9	12.0	13.2	4.0 × 8.0	8.0	10.5 × 6.6
vi)	4.00	0.80	—	—	—	—	—	—	—	—	—	—	4.8 × 9.6	9.6	12.0 × 7.4

**Table 8 Flexible Halogen Free Flame Retardant (HFFR)
Insulated and Sheathed Cables (Circular)**
(Clause 15.2, 15.4 and 15.5)

Sl No.	No. of Cores	0.50 sq. mm			0.75 sq. mm			1.0 sq. mm			1.5 sq. mm			2.5 sq. mm		
		Nominal Thickness of Insulation (t_i)	Nominal Thickness of Sheath (t_s)	Overall Dimensions Max..	Nominal Thickness of Insulation (t_i)	Nominal Thickness of Sheath (t_s)	Overall Dimensions Max..	Nominal Thickness of Insulation (t_i)	Nominal Thickness of Sheath (t_s)	Overall Dimensions Max..	Nominal Thickness of Insulation (t_i)	Nominal Thickness of Sheath (t_s)	Overall Dimensions Max..	Nominal Thickness of Insulation (t_i)	Nominal Thickness of Sheath (t_s)	Overall Dimensions Max..
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
i)	6	0.6	0.9	9.5	0.6	1	10.0	0.6	1	10.5	0.6	1	12.5	0.7	1.1	14.7
ii)	7	0.6	0.9	9.5	0.6	1	10.0	0.6	1	10.5	0.6	1	12.5	0.7	1.1	14.7
iii)	8	0.6	1	11.1	0.6	1	11.3	0.6	1	12.4	0.6	1.1	14.9	0.7	1.2	17.5
iv)	9	0.6	1	11.3	0.6	1.1	12.4	0.6	1.1	13.1	0.6	1.1	15.8	0.7	1.3	18.5
v)	10	0.6	1	12	0.6	1.1	12.7	0.6	1.1	13.4	0.6	1.1	16.2	0.7	1.3	18.9
vi)	11	0.6	1	12	0.6	1.1	12.7	0.6	1.1	13.4	0.6	1.1	16.2	0.7	1.3	18.9
vii)	12	0.6	1	12.4	0.6	1.1	13.1	0.6	1.1	13.9	0.6	1.1	16.7	0.7	1.3	19.5
viii)	13	0.6	1	13.1	0.6	1.1	13.3	0.6	1.1	14.6	0.6	1.2	17.5	0.7	1.3	20.7
ix)	14	0.6	1.1	13.1	0.6	1.1	13.3	0.6	1.1	14.6	0.6	1.2	17.5	0.7	1.3	20.7
x)	15	0.6	1.1	13.5	0.6	1.2	14.3	0.6	1.2	15.1	0.6	1.2	18.8	0.7	1.4	21.5
xi)	16	0.6	1.1	13.3	0.6	1.2	14.5	0.6	1.2	15.4	0.6	1.2	18.6	0.7	1.4	21.9
xii)	17	0.6	1.1	14.6	0.6	1.2	15.4	0.6	1.2	16.3	0.6	1.3	19.7	0.7	1.4	23.2
xiii)	18	0.6	1.1	14.6	0.6	1.2	15.4	0.6	1.2	16.3	0.6	1.3	19.7	0.7	1.4	23.5
xiv)	19	0.6	1.1	14.6	0.6	1.2	15.4	0.6	1.3	16.3	0.6	1.3	19.7	0.7	1.4	24
xv)	20	0.6	1.2	15.4	0.6	1.3	16.3	0.6	1.4	17.3	0.6	1.4	20.9	0.7	1.5	24.5
xvi)	21	0.6	1.2	15.4	0.6	1.3	16.3	0.6	1.4	17.3	0.6	1.4	20.9	0.7	1.5	25.2
xvii)	22	0.6	1.2	16.3	0.6	1.3	17.3	0.6	1.4	18.2	0.6	1.4	22.1	0.7	1.5	26
xviii)	23	0.6	1.2	16.3	0.6	1.3	17.3	0.6	1.4	18.2	0.6	1.4	22.1	0.7	1.5	26.5
xix)	24	0.6	1.2	17.1	0.6	1.3	18.2	0.6	1.4	19.2	0.6	1.4	23.2	0.7	1.5	27.4
xx)	25	0.6	1.2	17.1	0.6	1.3	19.0	0.6	1.4	19.2	0.6	1.4	23.2	0.8	1.5	28.1

Table 9 Recommended Lay-up of Cores
(Clause 14.3 and 15.3)

No. of Cores	Lay-up
2	2
3	3
4	4
5	5
6	D ¹⁾ -6
7	1- 6
8	1-7
9	1-8
10	2-8
11	3-8
12	3-9
13	3-10
14	4-10
15	5-10
16	5-11
17	5-12
18	D ¹⁾ -6-12
19	1-6-12
20	1-7-12
21	1-7-13
22	2-7-13
23	2-8-13
24	2-8-14
25	2-8-15
¹⁾ Dummy core with HFFR property.	

ANNEX A

(Clause 4.2.1)

HALOGEN FREE FLAME RETARDANT INSULATED CABLES

Sl No.	Test	Unit	Test Method	Type of Insulation		
				HFI-TP70	HFI-XL70	HFI-XL90
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A	General					
1	Rated temperature			70°C	70°C	90°C
2	Insulation resistance constant at rated temp.	MΩ.km	IS 10810-43	Min. 0.037	Min. 0.037	Min. 0.037
	Temperature	°C		70 ± 2	70 ± 2	90 ± 2
	Test duration	Hr.		1	1	1
3	Properties before ageing					
3.1	Values to be obtained for the tensile strength: - Min.	N/mm ²	IS 10810-7	7.5	10	10
	Values to be obtained for the elongation at break: - Min.	Percent		150	125	125
3.2	Properties after ageing in air oven		IS 10810-11			
	Ageing conditions: - temperature - duration of treatment	°C h		80 ± 2 168	100 ± 2 168	135 ± 2 168
	Value to be obtained for the tensile strength: - Min. - variation, Max.	N/mm ² Percent		— ± 20	— ± 30	— ± 30
	Values to be obtained for the elongation at break: - Min. - variation, Max.	N/mm ² Percent		— ± 20	— ± 30	— ± 25
4	Hot Deformation Test		IS 10810-15			
	Temperature	°C		80 ± 2	—	—
	Period of test	Hr.		4	—	—
	Result	Percent		Max. 50	—	—
5	Hot set test		IS 10810-30			
	Temperature	°C		—	200 ± 3	200 ± 3
	Period under load	Min		—	15	15
	Mechanical stress	N/cm ²		—	20	20
	Elongation under load, Max.	Percent		—	175	175
	Permanent Elongation, Max.	Percent		—	15	15
6	Cold Bend Test		IS 10810-20			
	Temperature	°C		-15 ± 2	-15 ± 2	-15 ± 2
	Period of test	h		3	3	3
	Result			No Cracks	No Cracks	No Cracks
7	Cold Impact test		IS 10810-21			
	Temperature	°C		-15 ± 2	-15 ± 2	-15 ± 2
	Period of test	h		3	3	3
	Result			No Cracks	No Cracks	No Cracks

Sl No.	Test	Unit	Test Method	Type of Insulation		
				HFI-TP70	HFI-XL70	HFI-XL90
(1)	(2)	(3)	(4)	(5)	(6)	(7)
8	Ozone resistance test		IS 10810-13			
	Temperature	°C		25 ± 2	25 ± 2	25 ± 2
	Duration	h		24	24	24
	Concentration	Percent		250 to 300 × 10 ⁻⁴	250 to 300 × 10 ⁻⁴	250 to 300 × 10 ⁻⁴
	Result			No Cracks	No Cracks	No Cracks
9	Assessment of halogen		5.7, Annex 4			
	pH	pH		>4.3	>4.3	>4.3
	Conductivity	µs/mm		<10	<10	<10
	HCL and HBr	Percent		<0.5	<0.5	<0.5
	HF	Percent		<0.1	<0.1	<0.1

ANNEX B

(Clause 4.5.1)

HALOGEN FREE FLAME RETARDANT SHEATHED CABLES

SI No.	Test	Unit	Test Method	Type of Sheathing			
				HFS-TP70	HFS-TP 90	HFS-XL70	HFS-XL90
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A	General						
1	Rated temperature	°C		70	90	70	90
2	Properties before ageing		IS 10810 (Part 7)				
2.1	Values to be obtained for the tensile strength: - <i>Min.</i>	N/mm ²		10	10	10	10
	Values to be obtained for the elongation at break: - <i>Min.</i>	Percent		100	100	125	100
2.2	Properties after ageing in air oven		IS 10810 (Part 11)				
	Ageing conditions: - temperature - duration of treatment	°C h		80 ± 2 168	100 ± 2 168	100 ± 2 168	100 ± 2 168
	Value to be obtained for the tensile strength: - <i>Min.</i> - variation, <i>Max.</i>	N/mm ² Percent		10 ± 25	10 ± 40	7 ± 30	10 ± 40
	Values to be obtained for the elongation at break: - <i>Min.</i> - variation, <i>Max.</i>	Percent Percent		100 ± 25	100 ± 40	125 ± 30	100 ± 40 ± 40
3	Hot deformation Test		IS 10810 (Part 15)				
	Temperature	° C		80 ± 2	90 ± 2	80 ± 2	90 ± 2
	Period of test	h		4	4	4	4
	Result	Percent		Max. 50 percent	Max. 50 percent	Max. 50 percent	Max. 50 percent
4	Hot set test		IS 10810 (Part 30)				
	Temperature	° C		—	—	200 ± 3	200 ± 3
	Period under load	Minutes		—	—	15	15
	Mechanical stress	N/cm ²		—	—	20	20
	Elongation under load, <i>Max.</i>	Percent		—	—	175	175
	Permanent Elongation, <i>Max.</i>	Percent		—	—	15	15
5	Cold bend test		IS 10810 (Part 20)				
	Temperature	° C		-15 ± 2	-15 ± 2	-15 ± 2	-15 ± 2
	Period of test	Hr.		3	3	3	3
	Result			No Cracks	No Cracks	No Cracks	No Cracks
6	Cold impact test		IS 10810 (Part 21)				
	Temperature	°C		-15 ± 2	-15 ± 2	-15 ± 2	-15 ± 2
	Period of test	Hrs.		3	3	3	3
	Result			No Cracks	No Cracks	No Cracks	No Cracks

Sl No.	Test	Unit	Test Method	Type of Sheathing			
				HFS-TP70	HFS-TP 90	HFS-XL70	HFS-XL90
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
7	Assessment of halogen		5.7, Annex D				
	pH	pH		$\text{pH} \geq 4.3$			
	Conductivity	$\mu\text{S}/\text{mm}$		≤ 10			
	HCL and HBr	Percent		≤ 0.5			
	HF	Percent		≤ 0.1			
8	Water immersion test (Effect of water on sheath)		5.13				
	Temperature	$^{\circ}\text{C}$		70	70	70	70
	Period of test	h		168	168	168	168
	Variation in TS	Percent		± 30	± 30	± 30	± 30
	Variation in elong. Percent	Percent		± 30	± 30	± 30	± 30
9	Ozone resistance test		IS 10810 (Part 13)				
	Temperature	$^{\circ}\text{C}$		25 ± 2	25 ± 2	25 ± 2	25 ± 2
	Duration	Hr.		24	24	24	24
	Concentration	Percent		$250 \text{ to } 300 \times 10^{-4}$	$250 \text{ to } 300 \times 10^{-4}$	$250 \text{ to } 300 \times 10^{-4}$	$250 \text{ to } 300 \times 10^{-4}$
	Result			No Cracks	No Cracks	No Cracks	No Cracks

ANNEX C

(Clause 8)

SAMPLING OF CABLES**C-1 LOT**

In any consignment the cables of the same size and type manufactured under essentially similar conditions of production shall be grouped together to constitute a lot.

C-2 SCALE OF SAMPLING

C-2.1 Samples shall be taken and tested from each lot for ascertaining the conformity of the lot to the requirements of the specification.

C-2.2 The number of samples to be selected shall depend on col 1 and 2 of the following table. These samples shall be taken at random.

C-2.3 In order to ensure the randomness of selection, procedure given in IS 4905 may be followed.

C-3 NUMBER OF TESTS AND CRITERION FOR CONFORMITY

From each of the drum/coils/reels selected according to col 1 and 2 of the above table, suitable lengths of test samples shall be taken. These test samples shall be subjected to each of the acceptance tests. A test sample is called defective if it fails in any one of the acceptance tests. If the number of defectives is less than or equal to the corresponding permissible number given in col 3 of the above table, the lot shall be declared as conforming to the requirements of the acceptance tests; otherwise not.

Scale of Sampling		
Number of Drums/ Coils/Reels in the Lot	Number of Drums/ Coils/Reels to be taken as Samples	Permissible Number of Defectives
(1)	(2)	(3)
Up to 50	3	0
51 to 100	5	0
101 to 300	8	0
301 and above	13	2

ANNEX D

(Clause 5.7)

ASSESSMENT OF HALOGENS**D-1 REQUIREMENTS****D-1.1** The insulation and sheath shall meet the type test requirements as given in the following table:

Sl No.	Test Method	Measure	Requirements
1	See D-2	pH and conductivity	pH $\geq$ 4.3 and conductivity $\leq$ 10 μ S/mm
2	IS 10810 (Part 59)	Chlorine and bromine content expressed as content of HCL	$\leq$ 0.5 percent
3a	See D-3	Presence of fluorine	If negative, stop further test. If positive, test as per 3b
3b	See D-4	Fluorine content	$\leq$ 0.1 percent

D-1.2 The material shall be tested as per given sequence as per the table given below:

Sl No.	Test Method	Measure	Requirements	Outcome
Step 0	See D-3	Halogen : Fluorine, chlorine and bromine	Negative value	If negative stop test – material accepted. If positive go to step 1
Step 1	See D-2	pH	pH < 4.3	Reject the material
			pH $\geq$ 4.3	Evaluate conductivity
		Conductivity	$\leq$ 2.5 μ S/mm	Accept no further testing required
			> 10 μ S/mm	Reject material
Step 2	IS 10810 (Part 59)	Chlorine and bromine content expressed as hydrochloric acid (HCl)	> 0.5 percent	Reject material
			$\leq$ 0.5 percent	See D-4
	See D-4	Fluorine content	> 0.1 percent	Reject material
			$\leq$ 0.1 percent	Accept material

D-2 DETERMINATION OF DEGREE OF ACIDITY OF COMBUSTION GASES FOR MATERIAL BY MEASURING pH AND CONDUCTIVITY**D-2.1 Test Method Principle**

The material under test shall be heated in a stream of dry air. The evolved gases shall be trapped by bubbling through wash bottles filled with distilled or demineralized water.

The acidity of the resulting solution shall be assessed by determination of its pH value. The conductivity of the solution shall also be determined.

D-2.2 Test Apparatus**D-2.2.1 General**

The apparatus is shown in Fig.2 to Fig.6.

The assembly of the components which constitute the test apparatus shall be leak-tight. The connecting

distances between the quartz glass tube and the first bottle and between subsequent bottles shall be as short as possible. Glass or silicone rubber tubing shall be used for these connections.

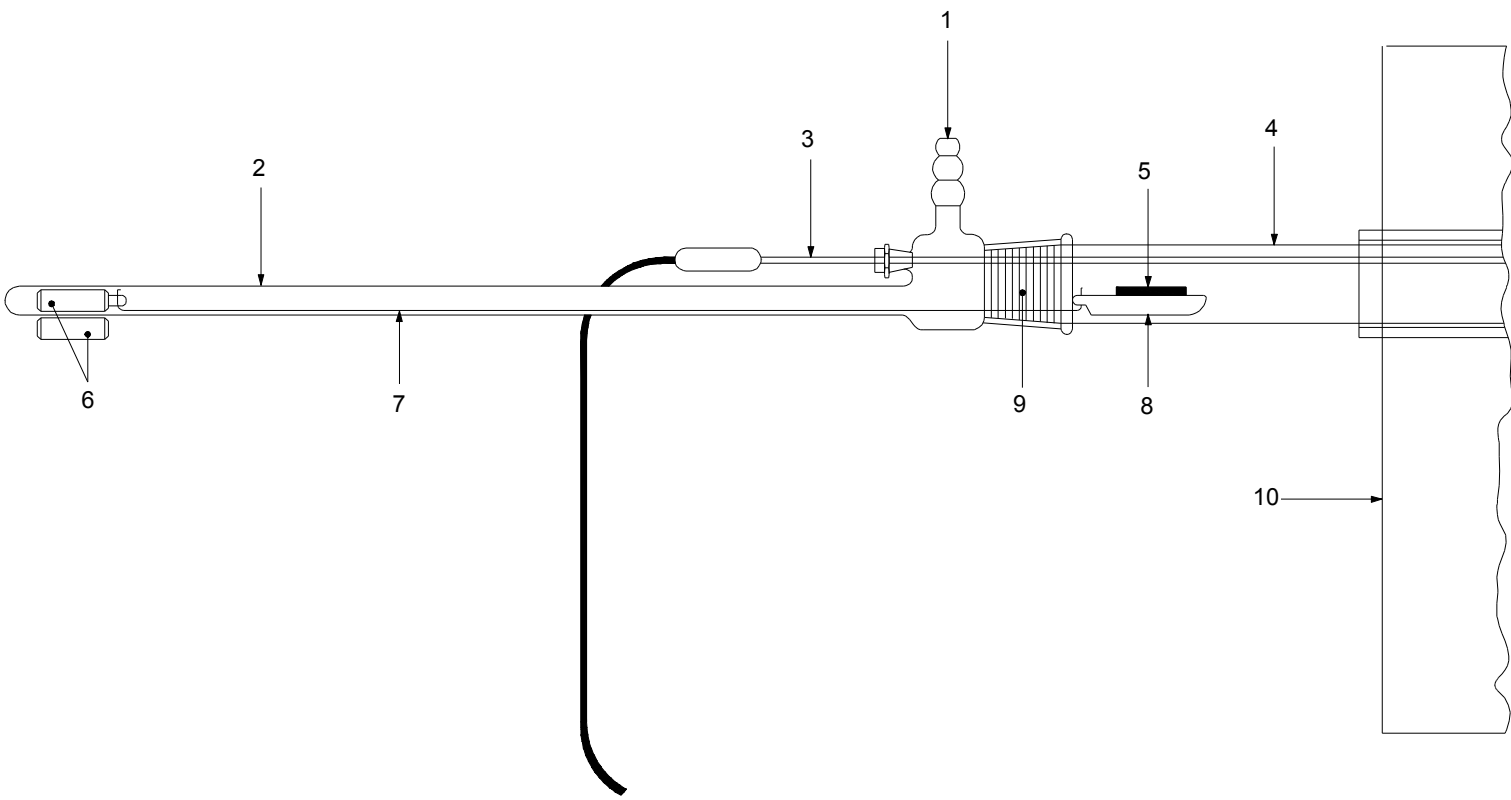
NOTES

1 At the exit side of the quartz glass tube, as close to the end as possible, it is permitted to place a plug of silica wool to aid collection of condensates.

2 A third empty bottle, of the same size as the gas washing bottles, placed before the gas washing bottles may be used to improve safety, that is to prevent suck back of water into the quartz glass tube.

D-2.2.2 Tube Furnace

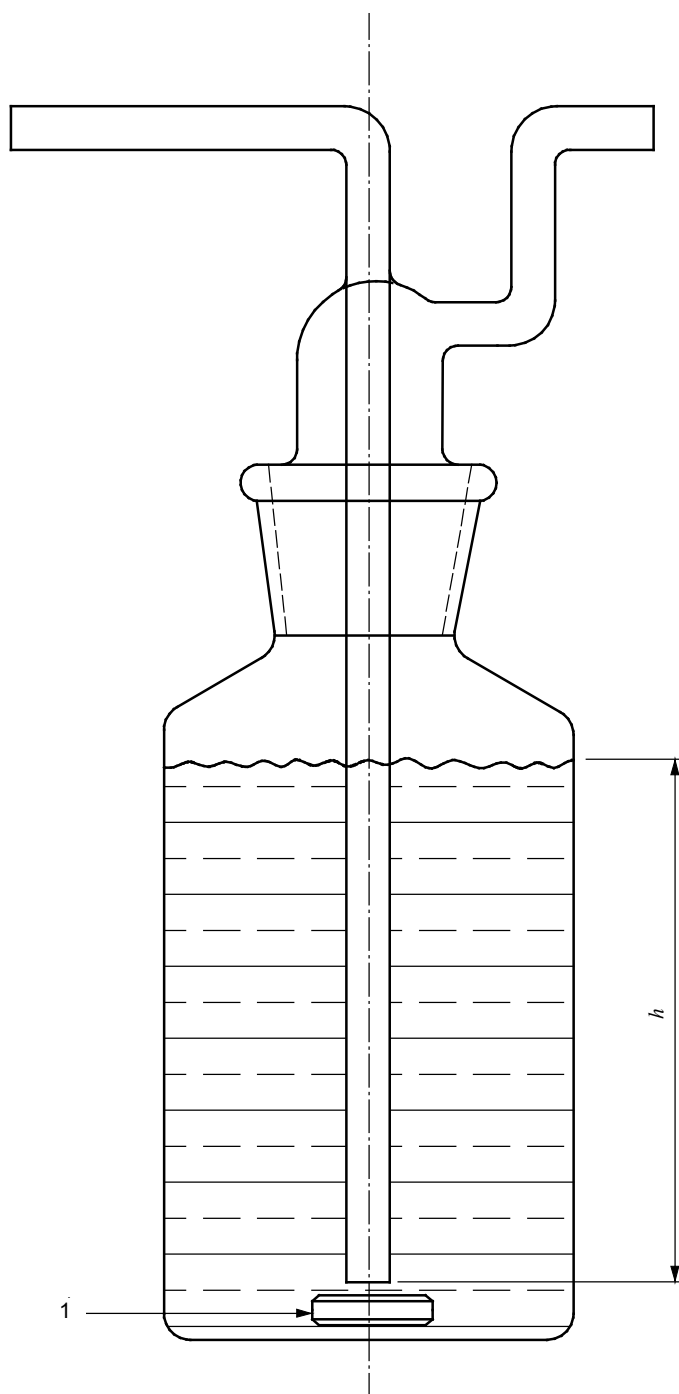
The length of the heating zone of the furnace shall be within the range 480 mm to 620 mm and its inside diameter shall be within the range 38 mm to 62 mm. It shall be equipped with an adjustable electrical heating system.



Key

- | | |
|---|---|
| 1 Synthetic air or compressed air, filtered and dried | 6 Bar magnets |
| 2 Glass tube | 7 Platinum wire |
| 3 Thermocouple | 8 Combustion boat |
| 4 Quartz glass tube | 9 Standard ground joint, size in correlation to the diameter of the quartz glass tube |
| 5 Test specimen | 10 Furnace |

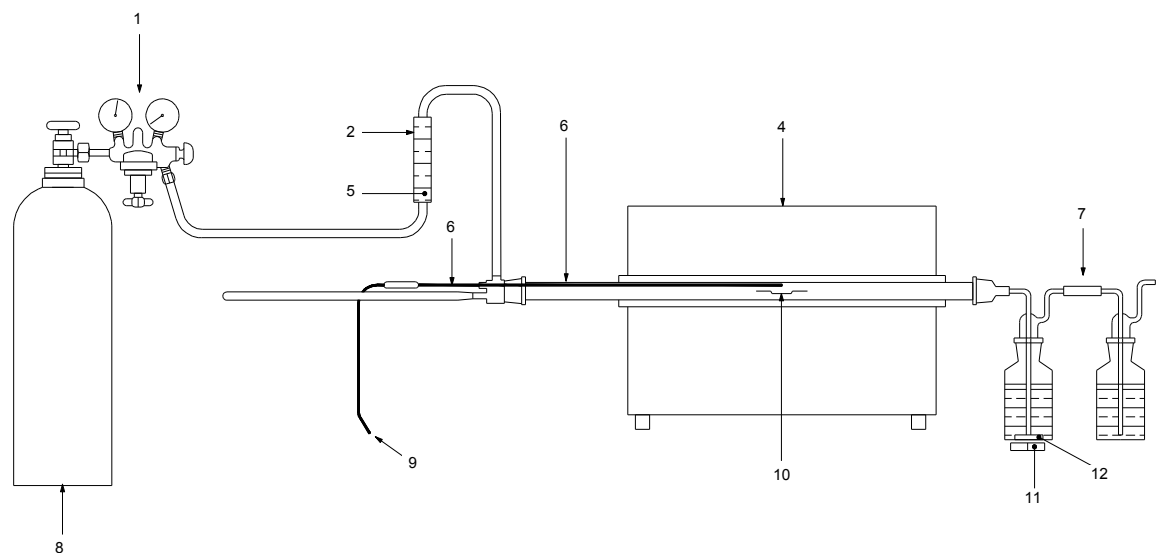
FIG. 2 DEVICE FOR INSERTING COMBUSTION BOAT AND TEST SPECIMEN



Key

1 Magnetic stirring bar h 100 mm to 120 mm

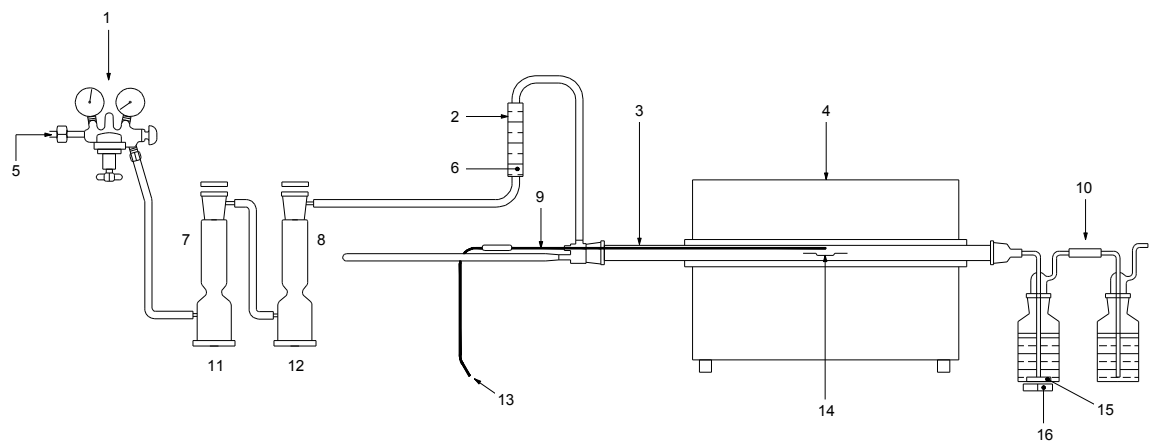
FIG. 3 EXAMPLE OF A GAS WASHING BOTTLE



Key

1	Pressure reducing valve	7	Gas washing bottles
2	Flow meter	8	Synthetic air
3	Quartz glass tube	9	Device for inserting combustion boat containing test specimen
4	Furnace	10	Combustion boat containing test specimen
5	Needle valve	11	Magnetic stirrer
6	Thermocouple	12	Magnetic stirring bar

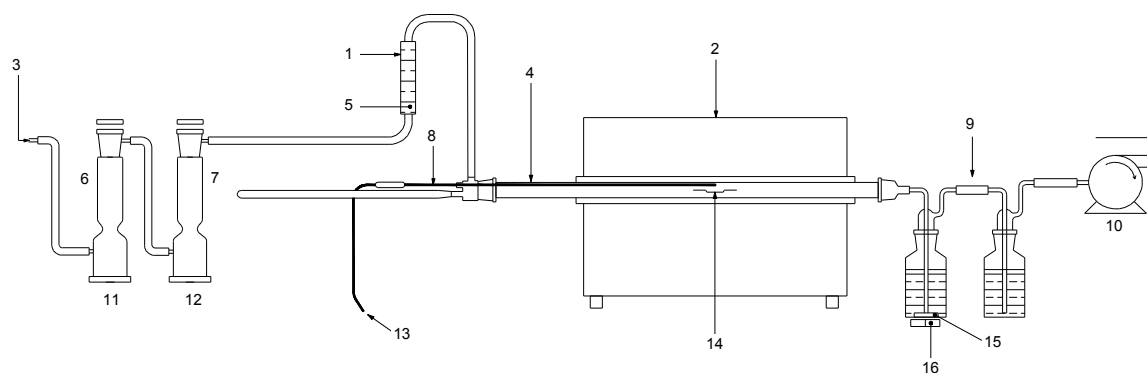
FIG. 4 TEST APPARATUS: METHOD 1 – USE OF SYNTHETIC OR COMPRESSED AIR FROM A BOTTLE



Key

1	Pressure reducing valve	7	Activated charcoal	13	Device for inserting combustion boat containing test specimen
2	Flow meter	8	Silica gel	14	Combustion boat containing test specimen
3	Quartz glass tube	9	Thermocouple	15	Magnetic stirring bar
4	Furnace	10	Gas washing bottles	16	Magnetic stirrer
5	Compressed air	11	Air filtering		
6	Needle valve	12	Air drying		

FIG. 5 TEST APPARATUS: METHOD 2 – USE OF LABORATORY COMPRESSED AIR SUPPLY



Key

1	Flow meter	7	Silica gel	13	Device for inserting combustion boat containing test specimen
2	Furnace	8	Thermocouple	14	Combustion boat containing test specimen
3	Ambient air	9	Gas washing bottles	15	Magnetic stirring bar
4	Quartz glass tube	10	Suction pump	16	Magnetic stirrer
5	Needle valve	11	Air filtering		
6	Activated charcoal	12	Air drying		

FIG. 6 TEST APPARATUS: METHOD 3 – USE OF AMBIENT AIR SUCKED BY MEANS OF A SUCTION PUMP

D-2.2.3 Quartz Glass Tube

For the test, a quartz glass tube shall be introduced into the tube furnace. The tube shall be approximately concentric to the furnace. It shall be resistant to the action of corrosive gases.

The inside diameter of the tube shall be within the range 30 mm to 46 mm. The tube shall protrude on the entrance side of the furnace by a length of between 60 mm to 200 mm, and on the exit side by between 60 mm to 100 mm. The initial clearance shall allow for thermal expansion. For the purposes of measurement of the protrusion distances, the tube shall be regarded as that part of essentially constant diameter.

NOTE — The outer diameter of the tube should be chosen with due regard to the inside diameter of the tube furnace.

Prior to each test the tube shall be cleaned throughout its length by being calcined at approximately 950°C.

D-2.2.4 Combustion Boats

The combustion boat shall be made of porcelain, fused quartz or soapstone and shall have the following dimensions:

- external length: within the range 45 mm to 100 mm;
- external width: within the range 12 mm to 30 mm; and
- internal depth: within the range 5 mm to 10 mm.

NOTE — The dimensions of the boat should be chosen with due regard to the inside diameter of the quartz tube.

The preferred method for insertion of the combustion boat into the quartz glass tube is shown in Fig.2.

Prior to each test, the combustion boat shall be washed and calcined in a muffle furnace at approximately 950 °C for 4 h after which it shall be introduced into a desiccator and cooled to ambient temperature. The combustion boat shall then be weighed to an accuracy of 0.1 mg until two identical consecutive weights are obtained. This weight m_1 shall be recorded.

D-2.2.5 Bubbling Devices for Gases

At the exit of the quartz glass tube, the evolved gases shall be trapped by bubbling through two wash bottles (see Fig. 3), each containing approximately 450 ml of distilled or demineralized water of a purity at least grade 3 in accordance with IS 1070.

The pH value of the water shall be 6.5 ± 1 , and the conductivity less than 0.5 $\mu\text{S}/\text{mm}$.

A magnetic stirrer shall be introduced in the first gas washing bottle to get a good swirling motion and an effective absorption of the combustion gases. The tubes into the wash bottles shall have a maximum internal diameter at their tip of 5 mm in order to aid absorption.

The height of the liquid above the end of the tube shall be (110 ± 10) mm in each bottle.

NOTE — Use of a standard laboratory glass bottle of internal diameter approximately 75 mm will enable this requirement to be met.

D-2.2.6 Air Supply System

The gas used for combustion shall be air.

The flow rate of air introduced into the quartz tube shall be adjusted according to the actual internal cross-sectional area of the tube, such that the speed of air flowing across the sample is approximately 20 ml/mm²/h.

The speed of air shall be regulated by reference to the flow rate of air. The flow rate of air shall be $(0.0157 \times D^2)$ l/h with a tolerance of ± 10 percent.

NOTE — The derivation of the flow rate of air from the speed of air is:

$$\rho = V \times \frac{\pi D^2}{4}$$

where,

D = internal diameter of the tube (mm);

ρ = flow rate of air (ml/h); and

V = speed of air (ml/mm²/h).

The air supply shall be adjusted and controlled by a needle valve, and the flow rate monitored by a flowmeter of the appropriate range.

The air supplied shall be selected from one of the following methods:

a) *Method 1*

This method uses synthetic air or compressed air from a bottle. The air shall be introduced on the inlet side of the quartz glass tube (see Fig. 4).

b) *Method 2*

This method uses a laboratory compressed air supply. Air shall be introduced on the inlet side of the quartz glass tube and shall be filtered and dried (see Fig. 5).

c) *Method 3*

This method uses the ambient air of the laboratory. The air shall be filtered and dried. In this case, the mixture of air and combustion gas shall be sucked by a pump (see Fig. 6).

D-2.2.7 Analytical Balance

The balance shall have a precision of ± 0.1 mg.

D-2.2.8 Laboratory Glassware

For pH and conductivity determination, the following laboratory glassware shall be available:

one mark volumetric flask in accordance of IS 915 with 1 000 ml capacity.

D-2.2.9 pH Meter

The pH meter shall have a precision of ± 0.02 and shall be equipped with a pH electrode.

D-2.2.10 Conductivity Measuring Device

The conductivity measuring device shall have a range of 10^{-1} μ S/mm to 10^{+2} μ S/mm and shall be equipped with an electrode.

D-2.3 Test Specimen**D-2.3.1 General**

Three test specimens for the general method, or two for the simplified method, each consisting of $(1\ 000 \pm 5)$ mg of the material to be tested, shall be prepared. Each test specimen shall be taken from a sample representative of the material. Each test specimen shall be cut into a number of smaller pieces.

NOTE — Pieces with a maximum dimension of 3 mm have been found to be suitable.

D-2.3.2 Conditioning of Specimen

The prepared test specimens shall be stored for at least 16 h at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) percent.

D-2.4 Test Procedure**D-2.4.1 General**

The test procedure and determination of pH value and conductivity value shall be carried out on each test specimen.

D-2.4.2 Test Apparatus and Arrangement

The test procedure defined in this clause shall be carried out using the apparatus detailed in **D-5**.

D-2.4.3 Heating Procedure

The air flow shall be adjusted by means of a needle valve to the value specified in **D-2.2.6** and shall be kept constant during the test.

The temperature shall be measured by a thermocouple suitably protected against corrosion and placed inside the quartz glass tube. The heating system shall be adjusted such that the temperature at the designated position for the boat shall be not less than 935°C and not more than 965°C. The temperature at a position 300 mm from the designated position in the direction of the air flow shall be not less than 900°C.

The boat containing the test specimen shall be quickly inserted into the heating zone of the tube to the designated position determined by the thermocouple measurement and the timer shall be started. The combustion boat shall be placed in such a way that the distance between the boat and the exit end of the effective heating zone is at least 300 mm. The effective heating zone is that zone

where a temperature of not less than 900 °C has been determined by the thermocouple measurement.

The combustion procedure, under the air flow condition, shall be continued for (30 ± 1) min in the furnace.

WARNING —The operator should take precautions, for example, the wearing of eye protection and suitable protective clothing, because certain materials ignite quickly, and can cause “blow back” of hot gases. Care should also be taken to avoid over-pressurization of the system, and to allow for venting of exhaust gases. Guidance on the avoidance of “blow back” is given in Note 2 of **D-2.2.1**.

D-2.4.4 Washing Procedure

Following the heating procedure, all the bottles used shall be disconnected, and the contents washed into a 1 000 ml volumetric flask. Using water with the properties given in **D-2.2.5**, the bottles, the connecting links and, after cooling, the end of the quartz glass tube including the silica wool (if used) shall also be washed into the flask, and the contents made up to 1 000 ml.

D-2.5 Determination of the pH Value and Conductivity

The pH shall be measured using a pH meter calibrated as proposed by the instrument supplier.

The pH value of the solution shall be determined at $(25 \pm 1)^\circ\text{C}$ in accordance with the test procedures as prescribed by the supplier of the measuring instrument.

Conductivity value measurements shall also be performed at $(25 \pm 1)^\circ\text{C}$ in accordance with the test procedures as prescribed by the supplier of the conductivity measuring instrument.

The pH value and conductivity value shall preferably be read by using automatic temperature compensation. If such a facility is not available, the values shall be read when the temperature of the solution is at $(25 \pm 1)^\circ\text{C}$.

NOTE — Automatic temperature compensation is usually an integral feature of the pH and conductivity measuring instruments.

D-2.6 Evaluation of the Test Results

From the two test determinations undertaken, the sample shall be considered to have met the performance requirement if both pH values are greater than or equal to the specified value and both conductivity values are less than or equal to the specified value.

D-3 DETERMINATION OF HALOGENS — ELEMENTAL TEST

Warning — Owing to its potentially hazardous nature the fusion operation should be carried out in a fume cabinet, using safety screen.

D-3.1 Equipment

- a) Bunsen burner;
- b) Glass test tubes of approximately 50 mm × 10 mm;
- c) Test tube holder;
- d) Evaporating basin / mortar;
- e) Wire gauge;
- f) Funnel; and
- g) Filter paper.

D-3.2 Materials

- a) Sample;
- b) Sodium metal;
- c) Nitric acid (5 percent);
- d) Aqueous silver nitrate (5 percent);
- e) Freshly prepared zirconium-alizarin red S reagent;
- f) Glacial acetic acid; and
- g) pH papers.

D-3.3 Procedure

D-3.3.1 Sodium Fusion

Place 200 to 250 mg of the sample into the bottom of a small soda glass test tube. Add 10 ml of de-ionized water to the evaporating basin and place this in the fume cupboard behind the safety screen. Whilst holding the test tube firmly with the test tube holder at an angle of 45° to 60° to the vertical, introduce a piece of freshly cut, clean sodium in size of a small pea (200 to 250 mg) into the mouth of the test tube without allowing it to come into contact with the sample directly. With the safety screen in place, heat the sodium gently until it melts and runs down on to the sample leading to vigorous reaction when the molten sodium reaches the sample in case of presence of halogen. Heat the test tube gently for about a minute, then more strongly until the lower 20 mm of the test tube glows red hot. Plunge the red hot tube into the water in the evaporating basin, immediately placing the gauze on the top, to prevent the loss of material when tube shatters on contact with water. Allow any unreacted sodium to react before grinding up the solution and glass. Filter and separate the filtrate into two equal portions.

D-3.4 Determination of Presence of Chlorine and Bromine

To the first portion of the filtrate, add sufficient nitric acid to make the solution acidic. Boil this total volume till reduced by half, to remove any hydrogen cyanide (HCN) or hydrogen sulfide (H_2S), if present, which

would interfere with the test. Add 1 ml of silver nitrate solution a white or yellowish precipitate indicates the presence of halogen (Cl, Br), in the original sample (if the liquor is decanted and the precipitate is white and readily soluble in dilute ammonia then chloride is present).

D-3.5 Determination of Presence of Fluorine

To the second portion of the filtrate, acidify with glacial acetic acid. Boil this solution until its total volume is reduced to half.

Add two to three drops of freshly prepared zirconium lake reagent (equal volume of):

- Alizarin solution : Prepared by mixing 0.05 gm alizarin Red – S in 50 ml distilled water.
- Zirconium solution : 0.05gm zirconium nitrate in 10 ml concentrated hydrochloric acid (HCL) diluted with 50 ml of distilled water.

Heat at 40°C for one hour. The presence of fluoride is indicated by the red/pink colouration being bleached to yellow.

D-4 DETERMINATION OF LOW LEVELS OF FLUORINE

D-4.1 Principle

D-4.1.1 General

The sample is burnt in an oxygen flask, and the resulting solution is used to measure the fluorine content. The fluorine content may be measured using either of the following methods:

- Method A — A fluoride ion selective electrode, or
- Method B — Colourimetrically, by formation of the blue-red oligomer fluorine blue complex.

D-4.1.2 Apparatus

- Oxygen flask;
- Pipettes; and
- Volumetric flasks.

NOTE — All apparatus used in the fluorine determination should be made of polycarbonate or polypropylene, as fluoride ions react with glassware.

For method A, ion selective electrode (fluoride) with suitable millivolt meter and for method B, visible spectrophotometer.

D-4.1.3 Reagents

- Method A: electrode filling solution — Buffer solution as recommended by electrode manufacturer.
- Method B: alizarin fluorine blue reagent — Dissolve 2.5 g alizarin fluorine blue complex in

15 ml 2 propanol plus 35 ml water. Filter before use.

- Standard fluoride solution prepared from sodium fluoride.
- Dodecanol.
- 0.5 M Sodium hydroxide solution.

D-4.2.2 Procedure

D-4.2.2.1 General

Place an accurately weighed sample of material (25 mg-30 mg) in a 1 l oxygen flask using 2 to 3 drops of dodecanol on the sample to assist burning. Add 5 ml of 0.5 M sodium hydroxide solution as absorbant. Burn the sample and allow mist to settle. Transfer the contents of the flask with minimum washing to a 50 ml volumetric flask and proceed with method A or B.

D-4.2.2.2 Method A — Ion selective electrode method fluoride

Add 5 ml of recommended/buffer reagent to the sample solution and washings, and make up to the mark. Construct a calibration curve for the fluoride ion electrode according to the manufacturer's instructions. Measure the fluoride concentration of the sample solution and calculate the percentage of fluorine in the sample.

D-4.2.2.3 Method B — Alizarin fluorine blue method

Add 5 ml alizarin fluorine blue reagent to the sample solution and washings and make up to the mark. Allow to stand for the colour to develop. Measure the absorbance of the solution at 630 nm using a 1 cm cell with water as blank.

Construct a calibration curve by suitably diluting the standard fluoride solution to give concentrations in the range 0 µg/ml to 2 µg/ml. Also measure the absorbance of a reagent blank using reagent and water only. Calculate the fluorine concentration in the sample.

D-4.2.3 Using this method, it is estimated that fluorine levels with values greater than 0.02 percent can be detected.

In order to determine total halogen content of the material under test, the methods described below in both a) and b) shall be used.

D-4.3 Acid Gas Generation

- Tests shall be performed in accordance with the method specified in IS 10810 (Part 59).
- Tests shall be performed in accordance with the method specified in D-2 .

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